A new genus and two new species of land snail from geographically remote lithorefugial habitats in Queensland including a remarkable range extension for *Quistrachia* Iredale, 1939 (Gastropoda: Eupulmonata: Camaenidae)

John STANISIC

Honorary Research Fellow, Biodiversity Program, Queensland Museum, PO Box 3300, South Brisbane, Qld 4101, Australia. Email: john.stanisic@qm.qld.gov.au

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ABSTRACT

One new genus and two new species of camaenid are described from geographically remote lithorefugial habitats in Queensland. The two habitats have contrasting environments characterised by radically different geology, climate and vegetation. *Lorelliana* gen. nov. is introduced to accommodate *L. hoskini* sp. nov. from the high rainfall, rainforest peppered, granitic lithorefugia of Cape Melville, Cape York Peninsula. *Quistrachia nevbrownlowi* sp. nov. is described from the quartzic limestone refugia of the low rainfall, often drought affected, spinifex grassland of Mt Unbunmaroo (= Black Mountain), south-western Queensland. The survival of each species is discussed in relation to the significance of lithorefugia as habitat for land snails in otherwise snail-hostile environments. ❐ *new genus, new species, Gastropoda, Camaenidae, lithorefugia.*

The Camaenidae is a family of land snails that is particularly diverse in the rainforests of eastern Queensland (Stanisic *et al.* 2010). Long recognised as a late Miocene invader from land masses to Australia's north (Bishop 1981; Solem 1992, 1997), the family has managed to radiate extensively in many areas of Australia. In eastern Australia camaenids are prominent snails in both the wetter humid coastal rainforests and the drier subcoastal and inland rainforests. Relatively few camaenids have made the transition to much drier eucalypt forests and woodland in eastern Australia. Greatest diversity occurs in the subtropical and tropical rainforests that range from central New South Wales to the Wet Tropics of northern Queensland. The two Queensland camaenids described herein occur in rocky habitats in geographically remote environments characterised by differing lithologies, vegetation and rainfall. In each case, adapting to life in lithorefugia has been critical to their survival.

Lorelliana hoskini gen. et sp. nov. occurs among the boulder strewn, rainforest habitats of the Melville Range, Cape York Peninsula. Cape York Peninsula is a bioregion characterised by extensive savanna woodlands. Humid tropical rainforest occurs mainly in the eastern ranges (McIlwraith Range, Iron Range), along some water courses (e.g. Wenlock River, Jardine River) and at the tip of Cape York (Lockerbie Scrub). Elsewhere along the east coast tropical rainforest occurs in remnant scattered pockets in gully or rocky headland environments such as those at Cape Melville. This area is subject to high annual rainfall which combined with the moisture retaining qualities of the granitic lithorefugia enables it to support tropical rainforest communities. Camaenid

diversity on Cape York reflects the pattern of scattered, relatively small rainforest patches and consequently is much lower than it is in the vast rainforest massif of the Wet Tropics…but local endemism is high. *L. hoskini* sp. nov. is one such endemic species.

At the other end of the climatic spectrum *Quistrachia nevbrownlowi* sp. nov. is described from the dry spinifex grasslands of Mt Unbunmaroo (= Black Mountain), via Boulia, south-western Queensland (SWQ). Here the annual rainfall is consistently very low in a pattern often compounded by extensive year-long droughts. *Q. nevbrownlowi* sp. nov. is shown to belong to a genus of land snail otherwise only present in the Pilbara and southern Kimberley, north-western Western Australia. This extraordinary disjunct distribution is unique to the family and is probably an artefact of a much wider generic distribution in the past that has been splintered by the continued aridification of the continent since the Miocene. The quartzic lithorefugium of Black Mountain would have been critical in the survival of the species in the face of this gradual but dramatic climatic shift.

MATERIAL AND METHODS

Material used in this study is held in the collections of the Queensland Museum (QMMO). Studies of shell characters were carried out on specimens in the museum's dry collection (RC) and anatomical studies were based on ethanol preserved samples (SC). Measurements of shell characters (height, diameter, umbilical width) were made using callipers with a precision of 0.01 mm. Whorl counts were made to the nearest 1/8 whorl. Several representatives of the species from their respective type localities were dissected and studied using a WILD M5 stereo microscope with drawing apparatus in order to confirm stability of reproductive structures.

SYSTEMATICS

Infraorder EUPULMONATA

Superfamily HELICOIDEA

Family CAMAENIDAE

Genus *Lorelliana* gen. nov.

Etymology. Named for Lorelle Holcroft, former deputy principal and teacher at Queensland's Samford State School in recognition of her efforts in science education.

Diagnosis. Shell medium sized, creamy yellow with reddish brown subsutural and peripheral spiral bands, acutely depressedly trochoidal with a sharply carinate periphery; protoconch smooth, teleoconch mainly smooth with vague radial growth ridges, base shiny; aperture ovately lunate, lip reflected; umbilicus small but open. Penis sheath present, thick-walled. Penis sub-cylindrical, internally with a dense pattern of rhomboidal pilasters, without verge or prominent pilaster. Epiphallus long with slender ascending arm, descending arm thick, folded within penial sheath, entering penis through a simple pore; epiphallic caecum present.

Type species. *Lorelliana hoskini* sp. nov.-herein designated.

Lorelliana hoskini sp. nov.
(Figs 1, 2A-C, 3)

Etymology. Named for Conrad Hoskin, in recognition of his work on Cape Melville boulder field vertebrates.

Preferred common name. Cape Melville Talus-snail.

Material examined. Holotype. QMMO85061, shell RC/animal SC, Cape Melville, Melville Range, FNQ, (14°17′55″S, 144°28′50″E), rainforest on rocky talus, on granite boulders, 10.ii.2013, coll. C. Hoskin, K. Aland. Height of shell 10.46 mm, diameter 15.84 mm, umbilical width 2.29 mm, H/D = 0.66, D/U = 5.68, number of whorls 4.125.

Paratypes. QMMO80774, shell RC/animal SC, same data as holotype; QMMO85060, 6RC, Cape Melville, Melville Range, FNQ, (14°17′55″S, 144°28′50″E), rainforest on rocky talus, in litter, 15.xii.2013, coll. C. Hoskin, H. Hines.

Diagnosis. As for genus.

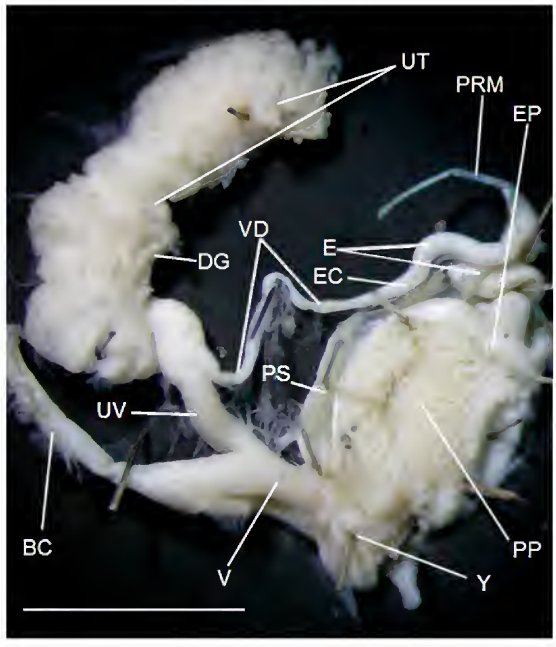

FIG. 1. *Lorelliana hoskini* gen. et sp. nov. QMMO85061, holotype. Genitalia. Scale line = 10 mm.

Description. Shell medium sized, creamy yellow with reddish brown subsutural and peripheral spiral bands, acutely depressedly trochoidal with a sharply carinate periphery, whorls 4.125-4.75 (mean 4.5), the last descending slightly in front; spire slightly elevated. Height of shell 7.67-8.44 mm (mean 8.11 mm), diameter of shell 17.34-18.80 mm (mean 18.10 mm), H/D = 0.43-0.47 (mean 0.45). Protoconch of 1¾ whorls, shiny, teleoconch mainly smooth with vague radial growth ridges, base shiny. Aperture ovately lunate, lip reflected, white; umbilicus small but open, umbilical width 2.03-2.66 mm (mean 2.37 mm), D/U = 6.81-8.54 (mean 7.74). Based on eight measured shells (QMMO80774, QMMO85060, QMMO85061).

Genitalia. Penis sheath (PS) present, thick-walled. Penis (P) sub-cylindrical, internally with a dense pattern of rhomboidal pilasters (PP), without verge or prominent main pilaster. Epiphallus (E) long with slender ascending arm, descending arm thick, folded within penial sheath, entering penis through a simple pore (EP); epiphallic caecum (EC) present. Vas deferens (VD) short. Penial retractor muscle (PRM) inserted on the epiphallus at the point of reflexion. Vagina (V) short, less than half length of penis, internally with longitudinal thickenings. Atrium (Y) simple. Free oviduct (UV) almost equal in length to vagina; bursa copulatrix (not figured) with a relatively wide stalk (BC) located at the base of the albumen gland; prostate (DG) and uterus (UT) without unusual features. Albumen gland, hermaphroditic duct and ovotestes not illustrated. Based on two dissected adults (QMMO80774, QMMO85061).

Animal. Animal (Fig. 3) orange with orange foot, black head and neck, upper and lower tentacles orange. Pallial region with black pallial collar and two black stripes running rearwards and located on either side of the pallial roof. Head wart present.

Habitat and ecology. Scattered patches of rainforest on granite talus; living among granite boulders.

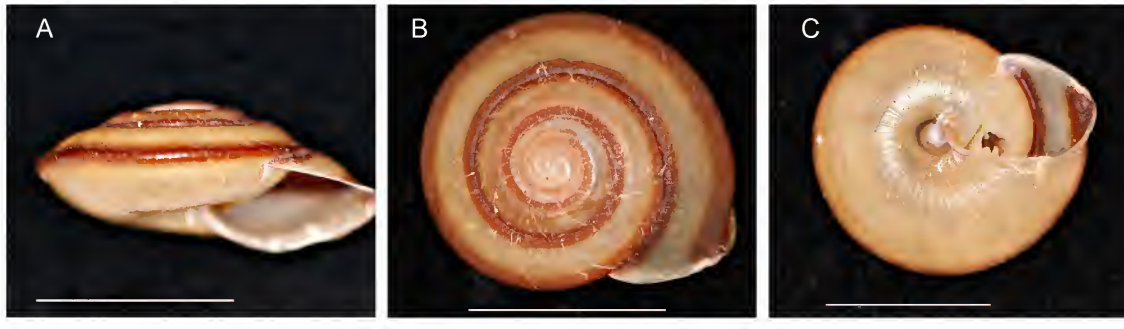

FIG. 2. *Lorelliana hoskini* gen. et sp. nov. QMMO85061, holotype. Shell views. **A**, apertural; **B**, dorsal; **C**, ventral. Scale lines = 10 mm.

FIG. 3. *Lorelliana hoskini* gen. et sp. nov. Live animal.

Distribution. Known only from the type locality.

Remarks. *Lorelliana hoskini* sp. nov. is endemic to the Melville Range boulder fields (Fig. 4) and can be readily distinguished by the combination of sharply carinate, very depressed, trochoidal shell and the orange animal with orange tentacles and black head. The relationships of the species are yet to be determined however, the short penis with a thick sheath, internal wall sculpture of dense rhomboidal pilasters, no verge and no main pilaster combined with an epiphallus which is partially folded within the penial sheath are a combination of anatomical characters which separate this species from all other Cape York Peninsula camaenids thus far dissected (Stanisic, unpubl.).

Interestingly the shell of *L. hoskini* bears an uncanny resemblance to that of *Trochomorpha melvillensis* Solem, 1989 (Family Trochomorphidae) which curiously comes from a somewhat similarly named locality in Melville Island (Tiwi Islands), Northern Territory. However, the superficial conchological resemblance between the two species is not reflected in vastly different shell sculpture and the contrasting anatomical details (Solem 1989).

Genus *Quistrachia* Iredale, 1939

Diagnosis. See Solem (1997).

Type species. *Trachia monogramma* Ancey, 1898-by original designation.

Quistrachia nevbrownlowi sp. nov.
(Figs 5A, B; 6A-C)

Etymology. Named for Neville Brownlow, Director of Earthborn Australia Pty Ltd, in recognition of his efforts in organic waste recycling.

Preferred common name. Boulia Globular Snail.

Material examined. Holotype. QMMO85063, shell RC/animal SC, Boulia, c. 50 km NE at Black Mt, SWQ, (22°33'03"S, 140°13'22"E), along creek in flood debris, 20.xi.2002, coll. R. Crookshanks. Height of shell 10.46 mm, diameter 15.84 mm, umbilical width 2.29 mm, H/D = 0.66, D/U = 5.68, number of whorls 4.625.

Paratypes. QMMO71806, 3SC, same data as holotype; QMMO71805, 4 SC, Boulia, c. 50 km NE at Black Mt, SWQ, (22°36'10"S, 140°13'32"E), along creek in flood debris, 20.xi.2002, coll. R. Crookshanks; QMMO72256, 6SC, Boulia, c. 50 km NE at Black Mt, SWQ, (22°38'27"S, 140°16'14"E), along creek in flood debris, 20.xi.2002, coll. R. Crookshanks; QMMO71807, 3SC/1RC, Boulia, c. 50 km NE at Black Mt, SWQ, (22°30'00"S, 140°16'30"E), along dry gully under dead spinifex, 20.xi.2002, coll. R. Crookshanks; QMMO4995, 50+ RC, AMSC.517369, 6RC; WAMS70841, 6RC; Black Mt, Warenda Station, c. 60 km NE Boulia, gibber and spinifex plain/limestone, on ground, alt. c. 180 m, viii.1971, coll. A. Hiller, M. Wade.

Other material. QMMO15053, 7SC, Black Mt, NE Boulia, WCQ, limestone area, viii.1984, coll. A. Rozefelds; QMMO85064, 4RC, locality given only as Queensland (= Black Mountain area, via Boulia), SWQ, 1975, coll. M. A. Archer.

Diagnosis. Shell medium-sized, with reddish brown suffusion on upper whorl surface extending below whorl periphery and a darker, narrow subsutural band and less prominent peripheral band, base white; helicoid with an elevated spire and rounded whorls; teleoconch sculpture of closely spaced, anastomosing radial ridges; aperture roundly lunate, lip white, expanded and reflected; umbilicus narrowly open. Penis with a thick sheath, internally with a main long, bifurcated pilaster, penis wall with

FIG. 4. Cape Melville boulders and rainforest. Image: Conrad Hoskin.

a series of longitudinally arranged diamond-shaped pustules merging into longitudinal pilasters basally. Vas deferens entering penis sheath basally and ascending almost entire length of penis, epiphallus short, entering penis apically through a simple pore; bursa copulatrix with a short stalk and expanded head located at the base of the prostate-uterus.

Description. Shell medium-sized, with reddish brown suffusion on upper whorl surface extending below whorl periphery and a darker, narrow reddish brown subsutural band and less prominent reddish brown peripheral band, base white; helicoid with an elevated spire and 4.125-4.625 (mean 4.5-) rounded whorls, the last descending slowly in front; spire moderately elevated. Height of shell 7.96-11.43 mm (mean 9.62 mm), diameter 13.15-16.94 mm (mean 14.72 mm), H/D = 0.58-0.69 (mean 0.65). Protoconch of 1½ whorls sculptured with irregular radial ridges, teleoconch sculpture of closely spaced, anastomosing radial ridges extending onto base. Aperture roundly lunate, lip white, expanded and reflected; umbilicus narrowly open, umbilical width 2.10-2.78 mm (mean 2.46 mm), D/U = 4.82-7.17 (mean 6.03). Based on 22 measured adults (QMMO4995, QMMO71807, QMMO85063).

Genitalia. Penis (P) with a thick sheath (PS), internally with main pilaster bifurcated (PPM), penis wall with a series of longitudinally arranged diamond-shaped pustules (PP) merging into longitudinal pilasters basally. Vas deferens (VD) entering penis sheath basally (VDE) and ascending almost entire length of penis. Epiphallus (E) short, entering penis

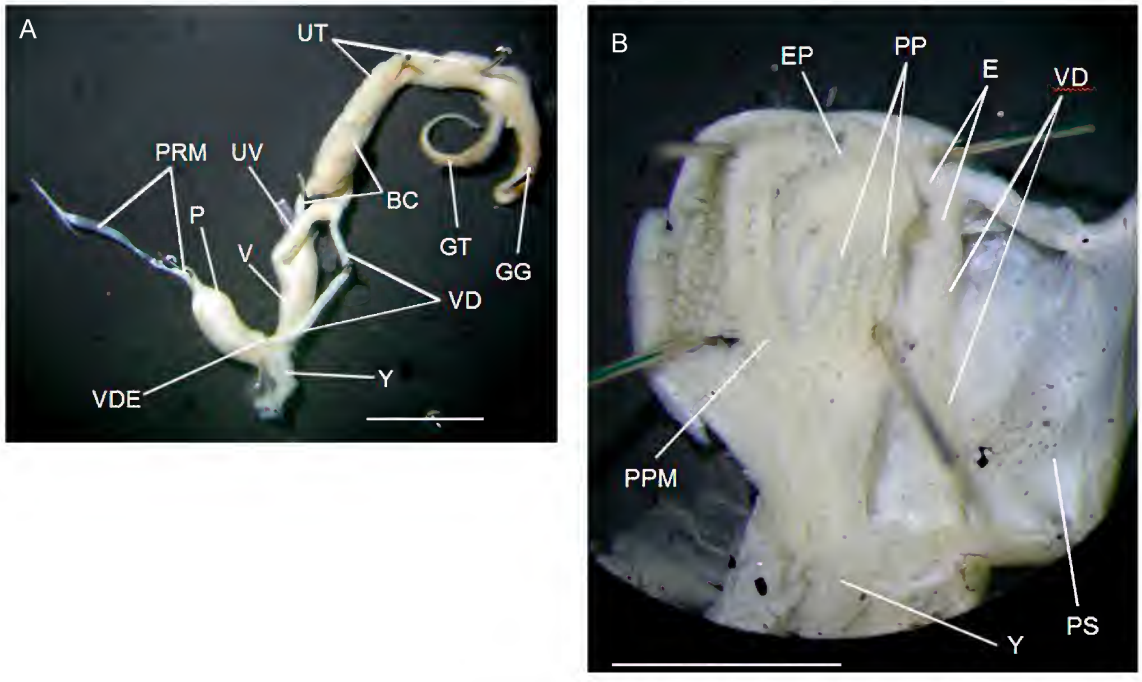

FIG. 5. *Quistrachia nevbrownlowi* sp. nov. QMMO71807, paratype. **A**, genitalia. Scale lines = 5 mm; **B**, penial complex. Scale lines = 2.5 mm.

apically through a simple pore (EP). Vagina (V) equal in length to the penis, internally with longitudinal thickenings, free oviduct (UV) relatively long; bursa copulatrix (BC) short with an expanded head located at the base of the prostate-uterus; prostate (DG) and uterus (UT) without unusual features. Albumen gland (GG) slender, hermaphroditic (GD) duct typical.

Animal. Preserved animal with light-brown body, head region slightly darker. Head wart absent.

Habitat and ecology. Spinifex on quartzic limestone; living under spinifex, rocks and scattered debris.

Distribution. Known only from Mt Unbunmaroo (= Black Mountain), NE Boulia, SWQ.

Remarks. *Quistrachia nevbrownlowi* sp. nov. has only been recorded in the vicinity of Mt Unbunmaroo (= Black Mountain), via Boulia, SWQ. The habitat is one of quartzic limestone

FIG. 6. *Quistrachia nevbrownlowi* sp. nov. QMMO85063, holotype. Shell views. **A**, apertural; **B**, dorsal; **C**, ventral. Scale lines = 10 mm.

TABLE 1. Local variation in shells of *Lorelliana hoskini* sp. nov. and *Quistrachia nevbrownlowi* sp. nov.

Taxon	N	Diameter (mm)	Height (mm)	Umbilical width (mm)	H/D ratio	D/U ratio	Number of whorls
L. hoskini sp. nov.							
QMMO85061 holotype	1	17.34	7.67	2.03	0.44	8.54	4.125
QMMO80774 paratype	1	18.80	8.44	2.36	0.45	7.97	4.375
QMMO85060 paratypes	6	17.52-18.80	7.69-8.36	2.23-2.66	0.43-0.47	6.81-8.43	4.5-4.75
Q. nevbrownlowi sp. nov.							
QMMO85063 holotype	1	16.59	10.65	2.79	0.64	5.95	4.625
QMMO4995 paratypes	20	13.15-16.94	7.96-11.45	2.10-2.78	0.58-0.69	4.82-7.17	4.125-4.625
QMMO71807 paratype	1	15.84	10.46	2.59	0.66	6.12	4.5

and spinifex grassland (Fig. 7). *Q. nevbrownlowi* is the sole outlier of a genus whose main mass of species (9) is located in the Pilbara, Dampierland and southern Kimberley of north-western Western Australia. The basal entrance of the vas deferens into the penial sheath, poorly defined epiphallus, bifurcated main penial pilaster and short bursa copulatrix are all features which clearly place the species in the otherwise Western Australian genus. The genital features most closely ally *Q. nevbrownlowi* to the Pilbara species *Q. legendrei* Solem, 1997.

Quistrachia nevbrownlowi was noted by Solem (1997:1876-1877) in his revision of *Quistrachia* but never described.

DISCUSSION

The present study highlights the importance of lithorefugia for the survival of land snails in two contrasting Queensland environments. The granite boulder fields of the Melville Range, Cape York Peninsula is in an area of relatively high annual rainfall (average annual rainfall > 1500 mm). The quartzic limestones of Mt Unbunmaroo (= Black Mountain) on the other hand have very low rainfall (mean < 250 mm per annum) with sporadic episodes of multi-year droughts. In the case of both *Lorelliana hoskini* sp. nov. and *Quistrachia nevbrownlowi* sp nov. these land snails have displayed resilience in the face of climatically induced, snail-hostile environmental change.

Lorelliana hoskini sp. nov. lives among the granite talus of Cape Melville in an area where rainforest has contracted and now occurs in gullies and on elevated plateaux within the boulder fields of the greater Melville Range, Cape York Peninsula (Fig. 8). Rainforest in eastern Australia receded into mountain top refugia and along moist drainage lines from the mid-Miocene onwards, and with greater amplitude and rapidity during the Quaternary (Galloway & Kemp 1981). Deeply layered rocky outcrops such as those in the Melville Range would have provided persistent moist and cool microhabitats for mesic organisms such as land snails (Couper & Hoskin 2008). Having a shell for protection and one which is designed for life in crevices (flattened) combined with a nocturnal habit would have pre-adapted the species for survival in such a specialised environment. Persistently high rainfall and shelter from fire would also have been major contributing factors. The area is already remarkable for the number of endemic vertebrate species (three frogs, two skinks and one gecko) all of which have connections with the rainforests of the Wet Tropics further south (Hoskin & Couper 2013; Hoskin 2013a, b, 2014).

FIG. 7. The spinifex covered terrain around Mount Unbunmaroo (= Black Mountain), via Boulia, SWQ. Image: Graham Harrington.

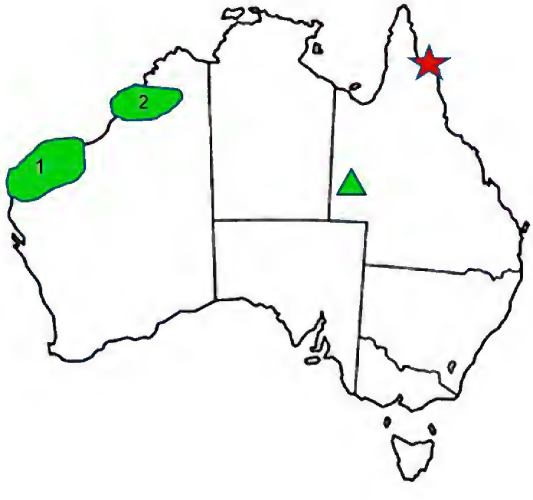

FIG. 8. Distribution map. *Lorelliana hoskini* gen. et sp. nov. (star): Cape Melville, north Queensland; *Quistrachia nevbrownlowi* sp. nov. (triangle): Mt Unbunmaroo, SWQ; Other *Quistrachia* spp., north-western Western Australia: 1, Pilbara; 2, Dampierland and southern Kimberley.

L. hoskini is the first endemic invertebrate thus far recorded from the locality. Its relationships are unknown at this time but may also lie within the Wet Tropics where much of the land snail fauna has yet to be collected let alone described.

Quistrachia nevbrownlowi sp. nov. lives among the limestone and spinifex of the Mt Unbunmaroo (= Black Mountain) area, via Boulia, SWQ. However, its nearest relatives are almost 2000 km away on the western edge of the continent, usually in the rocky talus strewn spinifex grasslands of the Pilbara and Kimberley of north-western Western Australia (Fig. 8). While some dry adapted pupillids bridge this geographic gap (*Glyptopupoides egregia*, *Gastrocopta* spp.) the distribution pattern is quite unusual in the context of the Camaenidae. There are camaenid genera such as *Torresitrachia* and *Xanthomelon* with so-called trans-Australian distributions (Solem 1979), but the range extension of a camaenid genus from its core in the Pilbara-Kimberley to a disjunct species in south-western Queensland, without any intervening congeners, is somewhat remarkable.

The extraordinary range disjunction between *Q. nevbrownlowi* and the main mass of *Quistrachia* species implies that there was once some historical connection of *Quistrachia* habitat between the two regions. It is reasonable to speculate that intervening species would have become extinct along with this historical habitat through climatic attrition in the face of widespread continental aridification. The onset of aridity was accompanied by extensive desertification in central areas of the continent whereby sand dunes covered much of the region. Survival of present day *Quistrachia* species relied on their ability to show resilience in the face of this aridification and adapt to life in scattered rock piles throughout the historical range. The availability of moisture and shelter sites among the rocky talus and the role of rock outcrops in excluding fire are all key attributes beneficial for the continued survival of land snails. That the current Western Australian species now live under rocks and litter among rock outcrops in the climatically challenging Pilbara and Kimberley is practical evidence for such a proposition. In an area of western Queensland that also endures unforgiving climatic conditions the presence of the limestone lithorefugium that is Black Mountain probably played a major role in the survival of *Q. nevbrownlowi*.

In conclusion, it should be added that this study once again underscores the part that land snails (and other invertebrates) can play in identifying places of environmental significance. These organisms are too often ignored in environmental survey and assessment. Yet they have the innate ability to identify special habitats in their roles as both environmental indicators and biodiversity predictors, in particular the moisture loving land snails.

ACKNOWLEDGEMENTS

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